PRELIMINARY OPERATING INSTRUCTIONS

MODEL 494A

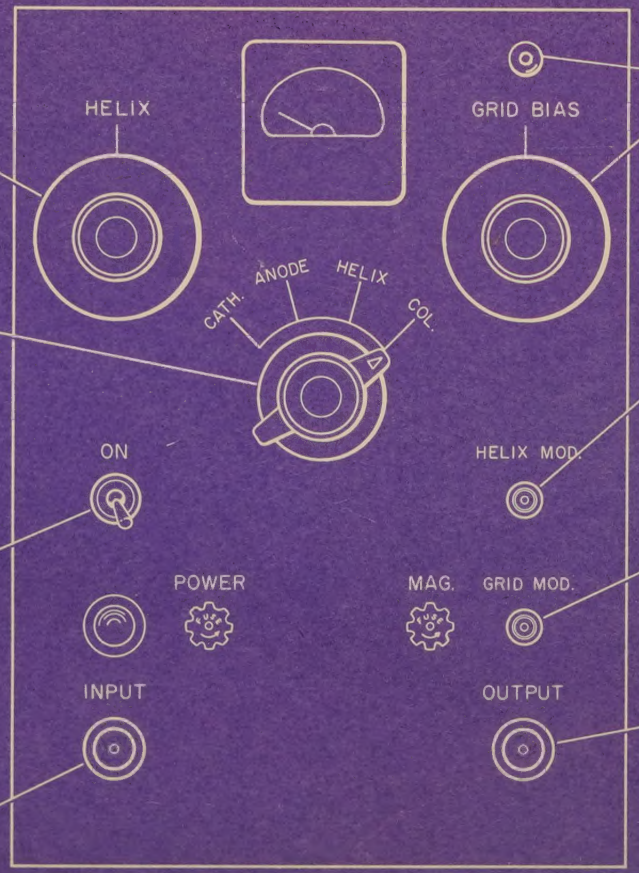
DESCRIPTION

The hp Model 494A traveling Wave Tube Amplifier is a broadband, linear, amplifier providing adjustable amplification up to 25 db or more, between 7,000 and 12,400 megacycles and has a maximum power output of at least 5 milliwatts to an external load of 50 ohms. The Model 494A is designed to be used also as a buffer-amplifier or modulator for any signal within its frequency range. As a modulator it can be used to amplitude, frequency, pulse, or phase modulate the signal being amplified with no interaction on the signal source. As a buffer its input impedance remains constant during modulation or with any reasonable load change at the output terminal, the attenuation between input and output signals being at least 60 db. Amplifier gain and power output are continuously adjustable by the front panel GRID BIAS control. Hum and spurious modulation generated within the amplifier are at least 35 db below the output signal level and the noise figure is less than 25 db.

As a broadband amplifier the 494A amplifies any type of r-f signal: c-w, swept, sine-modulated, pulsed, multiple signals on different frequencies, etc. As a modulator, the 494A, in conjunction with a signal generator, can be used to amplitude modulate an r-f carrier to approximately 30% with less than 2.5% harmonic distortion and up to 50% with less than 15% distortion. Phase modulation up to 360° with less than 2 db attendent amplitude modulation is also possible. Wide-band frequency modulation is simulated by a step-wise phase modulation. Pulse modulation is excellent, the rise time is less than 15 millimicroseconds. Amplitude modulation sensitivity approaches 1 db/volt, with an input terminal resistance of 0.1 megohm. Phase modulation sensitivity is approximately 40 V at 7 kmc to 25 V at 12.4 kmc volts peak-to-peak for 360° phase shift, with an input terminal resistance of 1.0 megohm.

Operation of the 494A is simple and straightforward. Input and output connections are made through type N panel connectors; modulation is introduced through BNC panel connectors. There are only two operating controls: the GRID BIAS control, for establishing correct bias during amplitude modulation or for gain adjustment, and the HELIX voltage control, for obtaining the flattest broadband characteristic or for optimizing the gain at some particular frequency. No further operating adjustments are needed. The impedance of the type N input and output connectors is nominally 53-ohm resistive load.

The front panel meter is provided for checking and adjusting electrode currents in the traveling-wave tube. The meter helps to obtain desired operating characteristics during normal operation of the amplifier and also assists with preventive maintenance and trouble shooting. An ANODE voltage adjustment on the instrument chassis can be adjusted to increase traveling-wave tube current if the maximum electrode currents decrease slightly due to aging.



(5) SET FOR BEST BROAD-BAND RESPONSE OR FOR MAXIMUM GAIN AT ANY ONE FREQUENCY

(2) SET TO CATH.

(4) CHECK ANODE, HELIX AND COL. CURRENTS.

(1) TURN ON ALL CIRCUITS OF AMPLIFIER. ALLOW 15 MINUTES WARM-UP.

(6) CONNECT TO SIGNAL SOURCE.

NOMINAL 50-OHM INTERNAL IMPEDANCE. USE WITH UG-21D/U CONNECTOR.

PIN JACK FOR MEASURING GRID BIAS. (MEASURES E_K; GRID GROUNDED)

(3) ADJUST FOR DESIRED TUBE CURRENT. NOT TO EXCEED MAX. ALLOWABLE CURRENT IN ANY ONE ELECTRODE. (SEE TEXT)

(8) INPUT FOR PHASE AND FREQUENCY MODULATION SIGNAL INPUT.

(9) INPUT FOR AMPLITUDE MODULATION SIGNALS.

(7) AMPLIFIED AND/OR MODULATED SIGNAL OUTPUT.

NOMINAL 50-OHM INTERNAL IMPEDANCE. USE WITH UG-21D/U CONNECTOR.

OPERATING INSTRUCTIONS AND APPLICATIONS

INSTALLATION

The only special precaution necessary for installing the 494A is that it should not be operated close to very large magnetic fields, such as 60-cycle fields, unless externally shielded. While the 494A is shielded within the cabinet, complete protection against large low-frequency fields would require more shielding than is practical to include in the design.

To operate the 494A, connect the instrument to a 115-volt a-c power source, check and adjust tube operating currents, as described below, and connect to the external equipment with coaxial cables terminated in standard UG-21D/U, type N connectors. The power cord for the 494A is terminated by a polarized, three contact plug for protection to operating personnel. This plug has an offset, round pin added to the standard two-contact a-c plug. The third contact grounds the instrument chassis when used with the appropriate a-c outlet. To use this plug in a standard two-contact a-c outlet, an adapter must be provided by the operator, or the round pin can be removed from the plug. When the adapter is used, the third contact is terminated in a "pigtail" which can be connected to the a-c outlet mounting box in order to ground the instrument chassis.

PRELIMINARY SETTING-UP PROCEDURE

The operating procedure for the 494A is given in Figure 1. Whenever the 494A is turned on, the current to each electrode in the traveling-wave tube should be measured with the front panel meter, with the GRID BIAS control set for zero bias.

The safe maximum current for each electrode is shown in the following table. Currents are usually high when the instrument is first turned on, but decreases to normal during warm-up. The currents may be reduced during warm-up by increasing GRID BIAS. Allow 15 minutes warm-up before making final setting.

The maximum cathode current that can flow is adjusted at the factory with the Anode voltage control on the instrument chassis. If following tube replacement or for some other reason, the cathode current can be increased with the GRID BIAS control to slightly above the safe maximum of 2 milliamperes, readjust the Anode voltage control. If the cathode current is limited to a safe maximum but the current to another electrode is excessive, the amplifier requires service or adjustment.

MAXIMUM OPERATING CURRENTS
DO NOT EXCEED

Total Cathode Current	=	not more than 2.0 milliamperes;
Collector current	=	not more than 1.7 milliamperes;
Helix Current	=	not more than .5 milliamperes;
Anode Current	=	should be 0; (separately adjustable)

ADJUSTING THE HELIX CONTROL

Adjusting the HELIX voltage control on the front panel maximizes the gain and power output of the 494A. With it, the gain of the traveling-wave tube can be peaked at a selected frequency or can be adjusted for flattest frequency response over the entire band. Maximizing the gain at frequencies below 12,400 megacycles usually results in additional gain and power output over that obtained when adjusted for flattest broadband operation. Adjusting the HELIX voltage control for maximum gain at 12,400 mc usually produces the flattest frequency response over the band. The final setting of the HELIX control is the same for all types of r-f signals modulated and unmodulated.

PRECAUTION WHEN APPROACHING MAXIMUM POWER OUTPUT

In practice, the 494A is usually capable of producing up to 5 milliwatts of output power, depending upon the frequency of the signal being amplified, the setting of the HELIX control and the characteristics of individual traveling-wave tubes. The absolute maximum output power is limited by tube saturation, and as saturation is approached, the traveling-wave tube becomes non-linear in the same manner as any vacuum-tube amplifier. Consequently, for linear operation, operate the 494A at output power levels 3 to 6 db below tube saturation. The effect of producing output signals above this level is to increase the harmonic content in the r-f output signal, and to increase modulation distortion when the r-f signal is being amplitude modulated. If the application is not concerned with harmonics or distortion of this sort (such as when pulse modulating) operation of the 494A up to and into saturation may be useful and is usually very satisfactory.

BANDWIDTH CONSIDERATIONS

To obtain the most nearly constant amplifier gain over the full frequency range adjust the HELIX voltage for maximum amplification at 12,400 megacycles. If it becomes necessary to hold the output amplitude more constant over an extremely wide bandwidth, see ℌ Application Notes, Traveling Wave Tube Amplifiers, page 2.

The extremely wide bandwidth of the 494A does not limit the amount of noise power in the output to the degree that a narrow band amplifier does, noise power being directly proportional to bandwidth. When the 494A amplifies or modulates signals only over a small portion of its frequency range, the HELIX voltage can be adjusted for best operation in this frequency range, and it may also be of value to install suitable filters at the output of the 494A to limit frequency coverage and reduce noise.

BUFFER APPLICATIONS

The 494A can serve as a very effective buffer to isolate a microwave signal source from a load. Mismatches, changes in external circuitry, or the introduction of modulation do not affect the constant 53-ohm input resistance of the 494A and thus will not affect a signal source connected to the input

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to the 494A. The attenuation between the output and input terminals is 60 db due to attenuators placed along the helix. However, when the output signal is reflected from a mismatched load back to the input, the effective signal isolation is the 60 db minus the gain of the amplifier. For example: with an amplifier gain of 30 db, an open or short circuit on the 494A output can result in a maximum change in input VSWR of only 6%.

AMPLITUDE MODULATION

The traveling-wave tube amplifier is particularly suitable for use as a modulated power amplifier following a microwave generator and permits the r-f output from an oscillator such as a klystron to be sine-wave or pulse modulated without the frequency shift, starting delays and jitter generally present when the oscillator itself is modulated.

The signal being amplified in the 494A is amplitude modulated by applying an a-c or d-c voltage to the GRID MOD. connector. This voltage varies the potential between the traveling-wave tube grid and cathode and consequently, the intensity of the electron beam, and output level from the tube. Any waveform — sine waves from d-c to above 100 megacycles, square or sawtooth waves or pulses can be applied to the GRID MOD. input connector.

To amplitude modulate the signal being amplified in the 494A proceed as follows:

a. Set the GRID BIAS control to zero bias. (max, cath. current).

b. Adjust the r-f input signal level to produce the desired output level below 5 milliwatts.

c. Apply the modulating signal to the GRID MOD. connector.

d. Adjust the modulation signal level to produce the desired percentage of modulation.

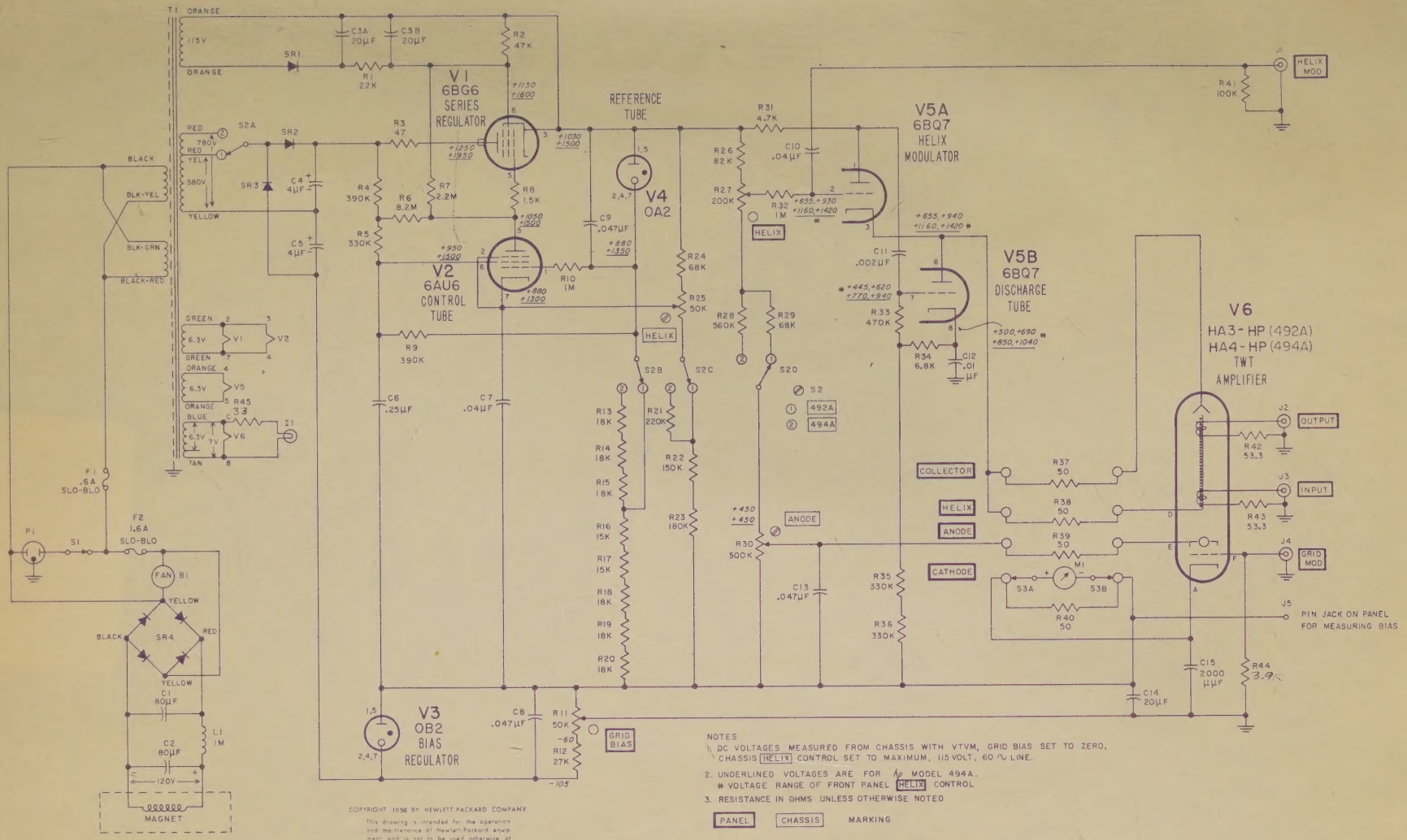
e. If higher than 50% modulation is desired set the GRID BIAS voltage control so that, at the most positive point on the modulation voltage swing, the grid voltage will not exceed approximately 5 volts positive. Beyond this grid voltage, the traveling-wave tube grid will draw current and cause serious distortion. Modulation percentages above approximately 50% result in rapidly increasing distortion.

SPECIFICATIONS

FOR

ⓗp 492A AND 494A TRAVELING-WAVE TUBE AMPLIFIERS

	492A	494A
FREQUENCY RANGE:	4 kmc to 8 kmc.	7 kmc to 12.4 kmc.
MAXIMUM GAIN:	At least 30 db.	At least 25 db.
OUTPUT POWER:	10 mw into 50 ohms.	5 mw into 50 ohms.
MODULATED PULSE DELAY:	20 millimicroseconds (approximately)	15 millimicroseconds (approximately)
HELIX MODULATION:	30v p-p (approx) to produce 360° phase shift	40v p-p (approx) to produce 360° phase shift
	20 cps to 1,000,000 cps; rise and decay each approximately 0.2 μ sec, Input resistance .1 megohm.	
INPUT IMPEDANCE:	Nominally 50 ohms, SWR less than 2.	
OUTPUT IMPEDANCE:	Nominally 50 ohms, SWR less than 3.	
AMPLITUDE MODULATION:	50 volt pulse produces a 40 db change in rf power level. Small signal sensitivity, 1 db/volt (approximately).	
MODULATED PULSE RISE AND DECAY TIME:	15 millimicroseconds each (approximately).	
NOISE FIGURE:	Less than 25 db.	
SPURIOUS MODULATION:	At least 35 db below output signal level.	
POWER REQUIREMENTS:	115 volts ± 10%, 50-60 cps, approximately 175 watts.	
SIZE:	7" wide, 10-3/4" high, 18" deep.	
WEIGHT:	55 lbs. net, 95 lbs. packed.	



NOTES

1. DC VOLTAGES MEASURED FROM CHASSIS WITH VTVM, GRID BIAS SET TO ZERO, CHASSIS HELIX CONTROL SET TO MAXIMUM, 115 VOLT, 60 ~ LINE.
2. UNDERLINED VOLTAGES ARE FOR hp MODEL 494A. # VOLTAGE RANGE OF FRONT PANEL HELIX CONTROL
3. RESISTANCE IN OHMS UNLESS OTHERWISE NOTED

PANEL CHASSIS MARKING

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hp MODEL 492A/494A

TRAVELING WAVE TUBE AMPLIFIER

SERIAL 1 & ABOVE

MP MASTER
MA24811